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The scale variation of barfin plaice *Liopsetta pinnifasciata* Kner, 1870 (Pleuronectidae, Pleuronectiformes)

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ABSTRACT

Objective: To investigate the scales of barfin plaice (*Liopsetta pinnifasciata*), which depends on the size and sex of the fish.
Methods: The samples were collected in Peter the Great Bay (Sea of Japan) during 2011–2014 aboard research vessels and at observation posts of Pacific Scientific Research Fisheries Center. In total, 155 specimens of barfin plaice were analyzed and 2 110 scales were investigated using MBS-10 binocular microscope.
Results: Temporal differentiations of scale forming is revealed for barfin plaice. The eye side of its juveniles is covered mostly with cycloid scales. Ctenoid scales are observed in elder fish with the minimum size of 11.4 cm and 13.5 cm for males and females, respectively. Sexual dimorphism of the scale structure is usual for mature fish. Ctenoid scales dominate 92.8% of the males but cycloid scales dominate 85.4% of the females. Besides, 74% of the males have ctenoid scales only, 42% of the females have cycloid scales only, and both types of scales are presented for 38.3% of the males and 38.4% of the females on average.
Conclusions: Juveniles of barfin plaice have cycloid scales only, the young immature fish, both males and females, have a small number of ctenoid scales, but ctenoid scales prevail in the adult males, while cycloid scales are still dominant for the adult females. However, many adults of both sexes have two types of scale simultaneously. The relative radius of the scales decreases with the increase of the body size.

1. Introduction

The variation in morphological scales is higher for Pleuronectidae as compared with other taxa of bony fishes and is distinguished by age dynamics and sexual dimorphism[1-4]. However, for the plaices of genus *Liopsetta,* the sexual dimorphism of scales is observed for mature fish only. Mostly, males have ctenoid scale and females have cycloid scale[5]. High variability of the scale structure is an important taxonomic feature of this genus but practically it cannot be used for its diagnostic[6]. Therefore, the variability of the plaice scales should be studied in detail, which is exactly the goal of this study for *Liopsetta pinnifasciata* (*L. pinnifasciata*).

2. Materials and methods

The samples were collected in Peter the Great Bay (Sea of Japan) during 2011–2014 both aboard research vessels and at observation posts of Pacific Scientific Research Fisheries Center. In total, 155 specimens of barfin plaice were analyzed by visually determining of their sexes after autopsy and measuring the absolute body length (TL)[7,8]. The scale samples were collected under the dorsal fin in the middle of the eye side of the body or above the lateral line for the fish with a size < 10 cm in the case of the scales which is absence under the fin. A total of 2 110 scales were investigated under MBS-10 binocular microscope and ScopeTek DCM 320 (3.2

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Mpix) and ScopeTek DCM 500 (5 Mpix) microscopes with digital cameras. On average, 15 scales per individual fish were collected. The software MICAM version 1.4 was used for the digital images capture and measurement and Faststone Image Viewer was used for improving quality of the images. The size of the scale was quantitatively described by its radius (R) and relative radius (R_r, ‰):

$R_r = (R/TL) \times 1\,000$

3. Results

Barfin plaice with the size of 2.6–32.7 cm was sampled, though it was known that it could reach 42 cm, with 0.5%–2.0% of the fish size > 33 cm[9-11]. The juveniles with the length of 2.6–11.6 cm had cycloid scales only under the dorsal fin on their eye side (Table 1), which corresponded with the results of Voronina and Evseenko[5] on *L. pinnifasciata* and arctic flounder *Liopsetta glacialis*, both for the sites at the dorsal and anal fins.

The scales were not formed at the same time, that is known for other species as well[12]. Taking the size and number of sclerites into account, the scales of fingerlings with the size of 2.6–4.6 cm and age of 2.5–3.5 months belonged to 2–3 groupings (Figure 1).

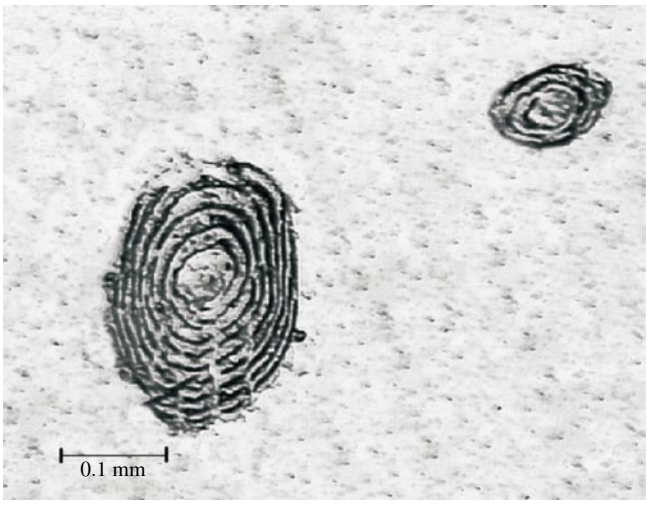

Figure 1. Fingerlings' scales of barfin plaice (*L. pinnifasciata*) aged 2.5–3.5 months (TL = 3.3 cm).
The large scales have 8 scale sclerites, and its side range is 0.088 mm; the small scales have 3 sclerites with a radius of 0.033 mm.

Barfin plaice spawns from January to March[13]. Its larvae are hatched from mid-April to mid-May and are observed in mass quantity in May[14]. The scale with a separate needle is classified as "actual ctenoid", following to Dgebuadze and Chernova[12], and the scale looking as bony plates of *Platichthys flounder* is classified as "strongly ctenoid", following to Voronina and Evseenko[5] (Figures 2 and 3). The minimum sizes of the plaice with ctenoid scales were 11.4 cm and 13.5 cm for males and females, respectively.

Table 1
Parameters of scales in different ontogenetic groups of barfin plaice (*L. pinnifasciata*).

Ontogenetic group	Body length (cm)	Parameters	1	2	3	Total
Juveniles	2.6–11.6 (4.3)	No. of specimens	19	0	0	19
		Percentage of specimens (%)	100	0	0	100
		Percentage of cycloid scales (%)	100	0	0	100
		No. of ctenii on ctenoid scales	0 (0)	0 (0)	0 (0)	
Immature males	10.1–14.4 (12.1)	No. of specimens	6	0	17	23
		Percentage of specimens (%)	26.1	0	73.9	100
		Percentage of cycloid scales (%)	100	0	67.4	75.9
		No. of ctenii on ctenoid scales	0 (0)	0 (0)	1–4 (1.2)	
Mature males	17.0–27.2 (21.6)	No. of specimens	2	37	11	50
		Percentage of specimens (%)	4	74	22	100
		Percentage of cycloid scales (%)	100	0	14.7	7.2
		No. of ctenii on ctenoid scales	0 (0)	1–6 (2.9)	1–6 (2.8)	
All males	10.1–27.2 (19.9)	No. of specimens	8	37	28	73
		Percentage of specimens (%)	11	50.7	38.3	100
		Percentage of cycloid scales (%)	100	0	46.7	58.4
		No. of ctenii on ctenoid scales	0 (0)	1–8 (3.1)	1–6 (2.3)	
Immature females	10.1–17 (12.7)	No. of specimens	16	0	4	20
		Percentage of specimens (%)	80	0	20	100
		Percentage of cycloid scales (%)	100	0	67.5	93.5
		No. of ctenii on ctenoid scales	0 (0)	0 (0)	1	
Mature females	19.3–32.7 (23.2)	No. of specimens	18	5	20	43
		Percentage of specimens (%)	41.9	11.6	46.5	100
		Percentage of cycloid scales (%)	100	0	72.8	85.4
		No. of ctenii on ctenoid scales	0 (0)	1–5 (2.6)	1–6 (2.4)	
All females	10.1–32.7 (20.1)	No. of specimens	34	5	24	63
		Percentage of specimens (%)	54	7.9	38.1	100
		Percentage of cycloid scales (%)	100	0	72.6	88.7
		No. of ctenii on ctenoid scales	0 (0)	1–5 (2.6)	1–6 (2.3)	

1: Individuals with cycloid scales only; 2: Individuals with ctenoid scales only; 3: Individuals with different types of scales; Values in parentheses are mean value.

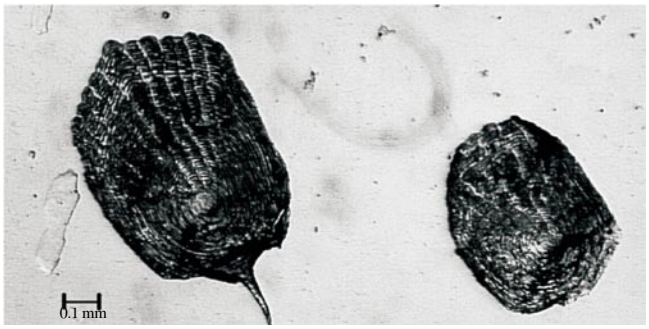

Figure 2. Scales of immature males of barfin plaice (*L. pinnifasciata*) at age of 1+ (TL = 14.4 cm).
Ctenoid and cycloid scales have 17 sclerites.

Figure 3. Scales of mature females (TL = 20.0 cm) (A) and mature males (TL = 19.0 cm) (B) of barfin plaice (*L. pinnifasciata*).

Young immature plaices had cycloid scales mostly (93.5% for females and 75.9% for males), though ctenoid scale began to appear when the females reached 13.5 cm and the males reached 11.4 cm, and 38.4 % of the females and 38.3 % of the males had both types of scales. However, there weren't observed immature males or females with the body covered with ctenoid scales only.

Sexual dimorphism of the scale structure was typical for mature fish only. Cycloid scale prevailed in 85.4% of adult females but ctenoid scale prevailed in 92.8% of adult males, and 42% of the females had cycloid scale only and 74% of the males had ctenoid scale only. Evseenko and Voronina concluded that all adult males of this species had the eye side covered by ctenoid scale only, but they have a limited number of samples[5].

Regardless of the type of scales, its shape was usually similar for each particular immature specimen. However, the shape variability increased with the growth of the fish. The majority of the adult females have some scales of 2–3 times smaller size and resorbed center among the bulk of large scales(Figure 3A), and the adult males with mixed types of scales had some small cycloid scales with partially fragmented, non-oval sclerites (particularly in the central part of scale) among large-sized ctenoid and cycloid scales (Figure 3B). The large-sized scales of the adult plaices had similar shapes for both types and sexes with some small differences that caudal edge of cycloid scale was less rounded and convex for the males (Figure 3B) than for the females (Figure 4A), and the ctenoid scale was less rounded and had more ctenii for the males as compared with females (Figures 4B and 4C). Besides, some large-sized scales had deformed sclerites (Figure 3B), which were the regenerating damaged parts supposedly[12].

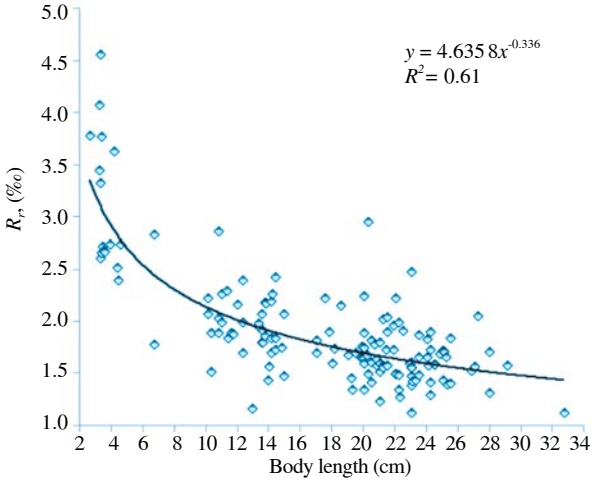

Figure 5. Relationship between the relative radius of scale (R_r, ‰) and fish body length (TL).

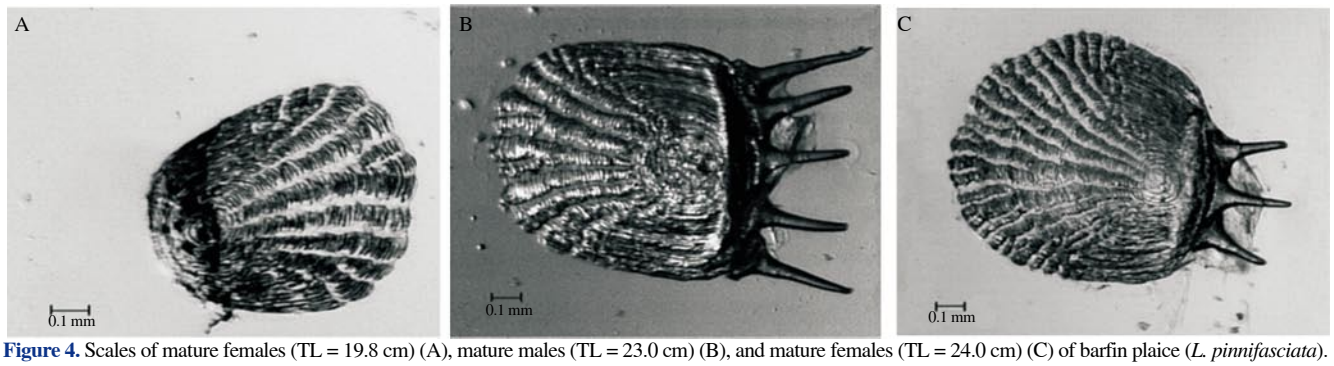

Figure 4. Scales of mature females (TL = 19.8 cm) (A), mature males (TL = 23.0 cm) (B), and mature females (TL = 24.0 cm) (C) of barfin plaice (*L. pinnifasciata*).

The scale of barfin plaice grows slower than the fish body (Figure 5), that's why its relative radius correlates negatively with the body length (r = -0.72): the relative radius ranged from 4.56‰ to 1.13‰ while the length of the fish was from 2.6 cm to 32.7 cm, and the biggest fish had the minimum radius. The relationship can be approximated by a power function, and using this function the decrease of the relative radius with the body length increasing to 42 cm could be estimated as 1.32‰. Taking this feature into account, we assume that the small-sized scales of adult plaices are probably new scales formed between "normal" scales rather than dropped scales, because barfin plaice has the scales firmly fixed in the skin pockets as well as other plaice species (even its trawl catches of the scale coverage of plaices is usually unbroken).

In our study, the "normal" large-sized scale prevailed, and most of the juveniles did not have the small-sized scale at all.

The proportion of ctenoid scale and the number of ctenii increased with age, particularly for the males, which had linear correlation between the number of ctenii and age with r = 0.87 as compared with r = 0.38 for the females (Figure 6). Following to this linear regression, the first ctenii forms when the male plaices reach the length of 8.8 cm, and each subsequent ctenoid spike forms after the length increasing by 4.4 cm. The maximum number of ctenii (8 pieces) was observed for one of scales of the biggest male in our sample (27.2 cm).

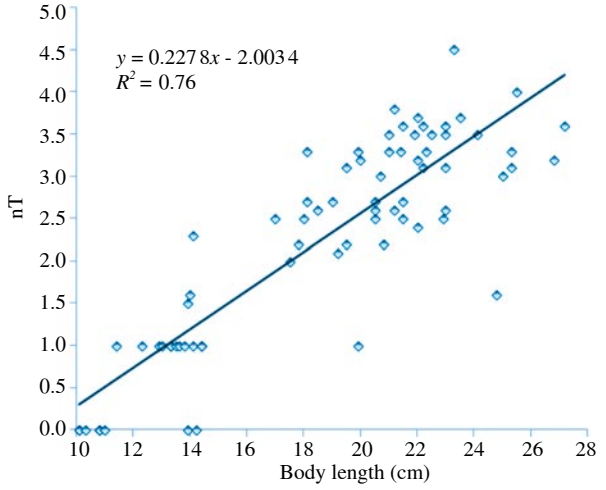

Figure 6. Relationship between mean number of ctenii on ctenoid scale (nT) and fish body length.

4. Discussion

To define, whether the scale structure could be used as a deterministic sign for gender differentiation, stability of its differences between the males and females of barfin plaices is considered. Ctenoid scales dominate the adult males (92.8%), while cycloid scales dominates the adult females (75.7%). The difference looks significant. However, some males of this species have mostly cycloid scale and some females have ctenoid scale. The total portion of the adult males with predominantly ctenoid scale is rather high (74.0%), but about a half (38.4%) of the females has both types of scales. Thus, the features of the scale structure are not opposite even for adults of barfin plaices. The variability of shape and size of the scales makes the situation more complicated. The ctenoid scale passes the stage of cycloid scale in its development (its minimal radius is 0.15 mm), and their absolute size and number of ctenii increases with the fish age (though the relative radius decreases). Moreover, the portion of ctenoid scale increases with the age for the males. So, the scale structure cannot be used for gender identification of a particular specimen of this species.

Conflict of interest statement

We declare that we have no conflict of interest.

Acknowledgments

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References

[1] Batts BS. Lepidology of the adult Pleuronectiform fishes of Puget Sound, Washington. *Copeia* 1964; **4**: 666-73.

[2] Ivankov VN, Ivankova ZG. [Sexual dimorphism in the flounders of the subfamily Pleuronectinae]. *Biologiya Morya (Vladivostok)* 1996; **22**(5): 328-9. Russian.

[3] Roberts CD. Comparative morphology of spined scales and their phylogenetic significance in the Teleostei. *Bull Mar Sci* 1993; **52**(1): 60-113.

[4] Tomiyama T. Sexual dimorphism in scales of marbled flounder *Pseudopleuronectes yokohamae* (Pleuronectiformes: Pleuronectidae), with comments on the relevants to their spawning behavior. *J Fish Biol* 2013; **83**(5): 1334-43.

[5] Voronina EP, Evseenko SA. [Morphology and systematics of the flatfish genus *Liopsetta* (sensu Norman, 1934) (Pleuronectidae, sensu Chapleau, Keast, 1988)]. *J Ichthyol* 2001; **41**(4): 442-54. Russian.

[6] Voronina E, Chanet B. Monophyly of the genus *Liopsetta* (Pleuronectidae). *Cybium* 2014; **38**(1): 43-52.

[7] Pravdin JF. [*Guide for studying the fishes*]. Moscow: Food Industry; 1966, p. 376. Russian.

[8] Tuponogov VN, Kodolov LS. [*Field identification guide of commercial and mass species of the Far Eastern seas of Russia*]. Vladivostok: Russian Island; 2014, p. 336. Russian.

[9] Sokolovsky AS, Sokolovskaya TG, Yakovlev Y. *Fishes of the Peter the Great Bay*. 2nd ed. Vladivostok: Nauka; 2011, p. 431.

[10] Vdovin AN, Mizyurkin MA, Pak A. [Opportunities of use of beam - trawl for the direct accounts of hydrobionts]. *J Ichthyol* 2009; **1**(37): 150-60. Russian.

[11] Vdovin AN. [On possibility to correct the size and age structure of fish in trawl catches]. *Fisheries* 2011; **6**: 55-7. Russian.

[12] Dgebuadze YY, Chernova OF. [*Scales of bony fish as a diagnostic and recording structure*]. Moscow: Tov. Nauch. Izd. KMK; 2009, p. 315. Russian.

[13] Pertseva-Ostroumova TA. [Reproduction and development far-eastern flounders]. Moscow: Akad. Nauk SSSR; 1961: 484. Russian.

[14] Nuzhdin VA. [Species composition and distribution of the winter-spring ichthyoplankton the northern area of the Japan Sea]. *Izvestiya TINRO* 1994; **115**: 92-107. Russian.